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Promotion of biofuel consumption in the transport sector: An EU-27 perspective

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ABSTRACT

The European Union's (EU) Directive 2003/30/EC [1] set an objective of reaching a 5.75% share of renewable energy as a proportion of the total energy consumption of the transport sector by 2010. As all the Member States (MSs) of the EU-27 were obliged to comply with this directive different public policy measures were developed and implemented to promote the use of biofuels in transport—biofuels being the main renewable energy source (RES) in this sector. In this article, we review the public measures undertaken in the EU-27, and show how these measures primarily involve tax incentives and biofuel blending mandates on fuel sales. All countries, with the exception of Finland, introduced tax incentives of various types to promote the use of biofuels, while 18 MSs also implemented biofuel blending mandates through the passing of legislation relating to this matter.

Contents

1. Introduction

The transport sector in the EU accounts for more than 30% of the total energy consumption, of which 98% is based on fossil fuels. The relevance of this sector and its energy consumption level across the EU has limited possibilities to meet the objectives and commitments of the Kyoto Protocol and have also intensified the degree of energy dependence in the EU (EU Biofuels Research Advisory Council) [2].

Directive 2003/30/EC [1] of the European Parliament and European Council concerning the promotion of the use of biofuels and other renewable fuels for transport, compelled the EU MSs to set their own objectives in relation to the percentages of renewable energy sources supplanting petrol and diesel use in the transport sector by 2005 and 2010. The initial reference amounts were 2% and 5.75%, respectively, of the total fuel consumption for this sector. Support for the use of biofuels in transport forms part of the EU strategy against climate change, but it also contributes to the reduction of EU dependence on external energy sources. Their use has thus become one of the main objectives of the EU energy policy.

According to the most recent data published by the European Commission [3], it is evident that a significant effort has been made since 2005 to reduce CO_2 emissions in the transport sector, leading to a diminution of their annual rates of increase. These rates have declined since 2008 when CO_2 emissions in the transport sector were reduced by 16.4 Mt, and further reduced to 26.6 Mt in 2009. Table 1 shows how this important contraction of emission output coincides with an increase of biofuel consumption in that sector. Between 2005 and 2010, biofuel consumption rose from 1.03% to

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Table 1
CO_2 emissions, fuel and biofuel consumption in the EU-27.
Source: Eurostat [5].

	2005	2006	2007	2008	2009	2010
CO_2 emissions (Mt)	949.86	955.08	962.80	946.37	920.74	n.a.
Fuel consumption (Mtoe)	299.08	304.80	308.98	305.63	300.47	299.71
Biofuel consumption (Mtoe)	3.10	5.49	6.74	9.55	11.90	13.27
Biof. cons./fuel cons.(%)	1.03	1.80	2.18	3.12	3.96	4.42

4.42% of the total fuel consumption by the transport sector, which is a little more than one percentage point short of the target of 5.75% for 2010 set by the 2003 biofuel Directive. However, this moderate reduction in fuel consumption has been observed since 2008 In fact, only a handful of countries have made the mark, just 7 of the 27, namely Sweden, Austria, France, Germany, Poland, Portugal and Slovakia (EurObserv'ER) [4].

Parallel to its role in the battle against climate change, the use of biofuels also contributes to another objective set by the Treaty of Lisbon: supply security or a reduction of the external energy dependence in the EU (Article 194) [6]. In 2010, biofuel use reduced the consumption of petrol and diesel in the EU by 2.79 Mtoe and 9.93 Mtoe, respectively. In addition to contributing to the attainment of the policy's two main objectives, biomass-based fuel use provides an alternative outlet for farm production and aids in the development of rural areas[1] .

In recent years, a large number of biofuel support policies have been put in place by the EU MSs, ranging from command and control instruments such as the fixing of standards and quotas, to economic and fiscal measures such as tax exemptions, through to information diffusion.[2] However, the two main instruments remain those of subsidisation through partial or total tax exemptions, and mandatory production by which fuel suppliers are obliged to achieve a certain biofuel share in their total sales. Both instruments can be complemented by a number of other incentives.

The aim of this article is to examine the measures implemented by the MSs of the EU-27 to promote the use of biofuels in the transport sector through until 2010, with a special focus on tax incentives and biofuel blending mandates. A thorough review of the literature on the topic has thus been made to identify the main policy measures implemented to support the uptake of biofuels. The principal references for this task, which are far from exhaustive, were the EREC country reports [11], ELOBIO reports (Pelkmans et al.) [12], the study by Wiesenthal et al. [9], the National Renewable Action Plans (nREAP) [13] and "Taxes in Europe" databases published by the European Commission [3], the EurObserv'ER database [4] and Kingman's database [14]. In addition, to understand the manner in which these policies have been implemented by each MS, the EU Directives on this issue and their transposition into national legislations have also been analysed.

Several previous works have focused on analysing public measures to promote the use of renewable energy sources for electric power production (among them, Del Río and Gual [15]; De Vries et al. [16]; and Cansino et al. [17]) and for use in heating and cooling Cansino et al.[18]; Pelkmans et al. [12] and Wiesenthal et al. [9] have also analysed the measures employed to promote biofuel consumption in the EU.[3] However, the former did not analyse those measures for the whole set of 27 MSs and the latter limited the period of study to pre-2006, thus excluding the important change of tendency observed in transport-related biofuel consumption since 2008. This article contributes to the literature by extending the work of Pelkmans et al. [12] by including data for all MSs, and that of Wiesenthal et al. [9] by increasing the number of years under study until 2010, thus including the 2007–2010 period, in which relevant changes took place in the price of feedstock and petrol, and in the budget framework of the MSs due to the impact of the global financial crisis.

The article is structured as follows. After the Introduction, Section "Community norms" details the most relevant EC norms on the subject. Section "Tax incentives" analyses the main tax incentives. Section "Biofuel blending mandates" examines national commitments in terms of biofuel blending mandates. Section "Discussion" presents a discussion of the results. The main conclusions of this work can be found in Section "Conclusions" .

2. Community norms

Directive 2003/30/EC [1] of the European Parliament and the European Council, which addresses the promotion of the use of biofuels or other renewable fuels for transport,[4] responded to the EU sustainable development strategy by setting the objective of promoting the use of biofuels or other renewable fuels as substitutes for diesel or petrol in the transport sector of the MSs.[5] This was done with a view to contributing to wider objectives such as compliance with climate change commitments, supply security in ecologically rational conditions, and promotion of the use of renewable energy sources (RES) (Article 1).

The Directive emphasised the need for MSs to achieve within their national markets the commercialisation of a minimum percentage of biofuels and other renewable fuels, establishing indicative objectives with the following reference values: 2% of all the fuel commercialised for transport by 31 December, 2005, and 5.75% by 31 December 2010 (Article 3.1.a). It also established the Commission's obligation to elaborate a biannual report addressed to the Parliament and the Council on the progress made by MSs in relation to the use of biofuels and other renewable fuels.

This policy of indicative objectives regarding the use of renewable energy in general, and of biofuels in the transport sector in particular, has evolved towards a policy of binding objectives, specified in Directive 2009/28/EC [20]. This new Directive

[1] See Skoulou et al. [7] for the Greek primary sector and kaygusuz [8] for a rural women perspective.

[2] Wiesenthal et al. [9] provides information about these complementary policies and measures: support to agricultural feedstock production in the framework of the Common Agricultural Policy, capital investment support to biofuel production facilities, and biofuel standards to stimulate the market-wide introduction of biofuels. In general, citizens support measures to biofuels promotions. For Greek case see Savvanidou et al. [10].

[3] Sorda et al. [19] offer an overview of biofuels politics across the world.

[4] Directive 2003/30/CE [1] will be revoked by Directive 2009/28/CE [20] as from 1 January, 2012.

[5] The role of EU as a leader in global environmental politics is analysed in Afionis and Stringer [21].

Table 2
Objectives for renewable energy participation as a percentage of final energy consumption in the transport sector (2005–2020).
Source: National Renewable Action Plans (nREAP) (2011).

	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Germany	3.9	7.3	7.5	7.6	7.0	7.0	7.0	7.1	9.3	9.4	9.7	13.2
Austria	2.3	6.8	6.9	7.0	7.2	7.4	7.7	8.1	8.5	9.2	10.1	11.4
Belgium	0.0	3.8	3.8	4.8	4.8	5.7	5.8	6.3	6.5	7.9	9.0	10.14
Bulgaria	1.12	1.3	2.0	2.6	3.1	3.8	4.4	4.9	5.8	6.4	7.0	7.8
Cyprus	0	2.2	2.4	2.5	2.8	2.9	3.1	3.5	3.8	4.2	4.6	4.9
Denmark	0.2	1.0	3.5	5.9	6.0	6.0	6.7	7.3	7.9	8.6	9.4	10.1
Slovakia	0.6	4.1	4.2	4.3	4.4	5.0	6.0	6.3	6.8	8.3	8.5	10.0
Slovenia	0.3	2.6	2.8	3.1	3.5	4.0	4.7	5.6	6.6	7.7	9.0	10.5
Estonia	0.0	0.0	0.0	0.6	1.2	1.3	1.3	1.6	1.8	2.1	2.4	2.7
Spain	1.1	6.0	6.1	6.5	6.5	8.2	9.3	10.4	11.1	12.0	12.7	13.6
Finland	0	6	7	8	10	11	12	14	15	17	18	20
France	1.2	6.5	6.9	7.2	7.5	7.6	7.7	8.4	8.8	9.4	10.0	10.5
Greece	0.02	1.7	3.3	4.1	4.8	5.6	6.3	7.1	7.8	8.6	9.4	10.1
The Netherlands	0.1	4.1	4.2	4.6	5.1	5.6	6.0	6.8	7.7	8.5	9.4	10.3
Hungary	0.22	3.7	4.6	5.0	5.0	5.2	5.4	5.8	6.4	7.3	8.0	10.0
Ireland	3.1	6.6	8.1	9.0	10.5	11.0	11.8	12.2	12.9	14.0	14.4	16.0
Italy	0.87	3.50	4.12	4.72	5.35	5.98	6.63	7.30	7.98	8.68	9.40	10.14
Latvia	0.9	4	4.1	4.2	4.4	4.5	4.6	5.5	6.3	7.2	8.2	10
Lithuania	0.3	4	4	5	6	6	7	8	9	10	10	10
Luxembourg	0.0	2.1	1.3	1.8	2.4	3.2	3.8	4.4	5.4	6.5	8.3	10.0
Malta	n.a.	2.8	3.0	3.3	3.6	3.9	4.2	4.6	5.8	7.1	8.2	10.7
Poland	n.a.	5.84	6.30	6.76	7.21	7.48	7.73	7.99	8.49	9.05	9.59	10.14
Portugal	0.19	5.0	5.1	5.3	5.7	5.9	8.0	8.2	9.0	9.3	9.7	10.0
United Kingdom	0.2	2.6	3.4	4.0	4.5	5.3	6.2	7.0	7.8	8.6	9.5	10.3
Czech Republic	0.1	4.1	4.6	5.2	5.9	6.5	7.1	7.7	8.3	9.6	10.2	10.8
Romania	1.39	5.82	6.37	6.90	7.32	7.72	8.11	8.43	8.80	9.23	9.69	10.00
Sweden	4.0	7.4	8.1	8.8	9.4	10.1	10.7	11.3	11.9	12.5	13.2	13.8

Note: Figures expressed as a percentage of final energy consumption in the transport sector.

established that, by the end of 2020, 10% of the energy consumed by the transport sector, in each and every MS, should come from renewable sources, mainly from biofuels and, additionally, from green electric power or hydrogen. This new objective for 2020 is much more ambitious than the one fixed for 2010 by Directive 2003/30/EC [1], and attempts to contribute in a more efficient manner to the following targets: (1) to reduce greenhouse gas (GHG) emissions by 20%, (2) to achieve a 20% participation of renewable energy sources in primary energy consumption, and (3) to reduce total energy consumption by 20%.

In order for MSs to reach these objectives, Article 4 of the above-mentioned Directive 2009/28/EC [20] stipulates the obligation of all EU countries to elaborate a National Renewable Action Plan (nREAP), with a view to lay down annual intermediate objectives in terms of proportions of renewable energy as a function of total energy consumption, disaggregated by sectors. Although most MSs did not submit their plan on time, all have now finally been submitted.

Table 2 outlines the intermediate objectives for the transport sector set by each country[6] in their respective action plans. Figures are shown as the RES percentage of final energy consumption in the transport sector. It can be seen that many countries anticipated their non-compliance with the objective fixed by Directive 2003/30/EC [1] for 2010, which was 5.75%. Only nine countries intended to comply with this objective on that date, with almost all other countries developing scenarios for 2020 in which their renewable energy participation is higher than or equal to the objective set by Directive 2009/28/EC [20]. Bulgaria, Cyprus and Estonia, however, do not expect to reach that minimum by 2020. The country with the most ambitious objective for 2020 is Finland, which hopes to reach 20%. Ireland (16%), Sweden (13.8%), Spain (13.6%), Germany (13.2%) and Austria (11.4%) follow some distance behind.

To achieve their objectives, MSs may use different energy sources, including biofuels (bioethanol, biodiesel and others), green electric power and hydrogen. Moreover, if their production levels are insufficient to achieve the consumption objectives established, the countries may import biofuels from other EU countries with a surplus of them, or from outside the EU if necessary. According to the nREAP, it is expected that by 2020 90% of the total renewable energy consumption in the transport sector will come from biofuels, in particular that of biodiesel.[7] Green electric power will represent less than 10% and there are no forecasts concerning the contribution of hydrogen. According to the available data, the volume of imports as a percentage of the total biofuel consumption required to meet the 2020 objectives set by the EU countries will average about 23%, although in some countries this may reach 100%. Those countries capable of reaching their consumption targets with a lesser volume of imports are Belgium, Spain, France, Malta and the United Kingdom. In contrast, Cyprus, Denmark and Luxembourg will have to import almost 100% of their consumption.

With the aim of allowing MSs to follow the implementation course that they themselves set down in their action plans, Directive 2009/28/EC [20] required that MSs transpose these commitments into national legislation prior to December 5, 2010. In this way, the specific norms in each country established, in addition to mandatory minimum objectives and accounting mechanisms used to control the amounts of energy that are sold or consumed, a system of certification that permits control of a country's compliance with the objectives.[8] Thus, for instance, in Spain, these issues were regulated by Order ITC/2877/2008 of

[6] All National Renewable Action Plans are continuously reviewed by each country and, if necessary, their estimated values are revised and resubmitted to the European Commission.

[7] In 2010, biodiesel represented 77.25% of the total biofuel consumption by the transport sector, while bioethanol represented only 21.10%. The remainder corresponded to vegetable oils and biogas (EurObserv'ER)[4].

[8] Articles 17 to 21 of Directive 2009/28/EC [20].

October 9, 2008 [22]. In Germany, they were regulated by two different orders, one on biomass sustainability (Biomassestrom-Nachhaltigkeitsverordnun-Bioster-NachV)[23] and one on biofuel sustainability (Biokraft-NachV) [24]. In the United Kingdom, the Renewable Transport Fuel Obligations Order 2007 regulated this matter (Upham et al.) [25].

3. Tax incentives

Within this legal framework, a large array of biofuel support policies has been implemented by the different MSs, ranging from command and control instruments such as standards and quotas, to economic and fiscal measures such as tax exemptions, through to information diffusion.

However, from the early 1990s two policies have been the main instruments articulating the biofuel support schemes of the EU: subsidisation to compensate for the extra costs associated with biofuels compared to fossil fuels,[9] and mandatory uptake in the market.[10] The first option has been usually implemented via tax incentives, while the second one requires that fuel suppliers achieve a certain biofuel share in their total sales. In any case, both instruments can be used by national authorities of the EU simultaneously with other support measures.

In this section, we focus on tax incentive policies designed to promote the use of biofuels in the transport sector up to 2010.

It can be seen from Pelkmans et al. [12] that MS strategies to reach biofuel targets differ significantly between countries. This situation is also observed in the cases of green electric power and RES for heating and cooling (H&C) (Cansino et al.) [17,18]. Some MSs focused mainly on pure biofuels, while others implemented programs that promote the blending of small amounts of biofuel with conventional fossil fuels. This section contains an updated overview in which we provide a comprehensive list of the main tax incentives involved.

In the particular case of biofuels, the application of tax exemptions or tax reductions for their promotion in the EU is feasible under the conditions settled by the EU Energy Taxation Directive.[11] The most relevant conditions are:

– The tax exemption or tax reduction must not exceed the amount of taxation payable on the volume of renewable energy used.
– Changes in raw material prices are accounted for in order to avoid overcompensation.
– The authorised tax exemption or tax reduction may not be
– lied for a period of more than six consecutive years, renewable.

In order to meet their own targets, the European governments adopted various proactive fiscal measures to promote the production and marketing of biofuels. Most MSs applied tax reliefs to their own excise duty on biofuels (Annexe A offers details of these tax reliefs and other tax incentives).

Tax reliefs are mainly applied to mineral oil duties (Austria, Belgium, Bulgaria, Czech Republic, Cyprus, Estonia, Germany, Greece, Hungary – until 2009 – Ireland, Italy, Latvia, Lithuania, Luxembourg, The Netherlands, Malta, Poland, Portugal, Romania, Spain, Slovakia, Slovenia, Sweden and the UK), although France also applies these relief measures to the domestic consumption tax. MSs usually apply a full exemption to pure biodiesel and partial exemption to blends.

Two MSs (Denmark and Lithuania) apply tax reliefs to environmental taxes. Poland also includes tax incentives in its corporate tax structure, and two MSs (Ireland and Spain) implemented tax reliefs in their national vehicle registration tax for flexible fuel vehicles (FFV). Although most of the tax reliefs are oriented to promote both biodiesel and bioethanol uptake, some MSs discriminate to benefit either biodiesel (i.e., Malta) or bioethanol (i.e., France and The Netherlands).

As most of the MSs now have a mixed scheme to promote biofuels, which is based on both tax incentives and/or a quota system, three of them (France, Germany and the Czech Republic; see Annexe A) reinforced this scheme by establishing a tax on the release for consumption of petrol and diesel.

Tax exemptions or tax reliefs are the most widespread fiscal incentives used to promote biofuels because they have an additional advantage compared to other alternative fiscal measures. As pointed out in Wiesenthal et al. [9], the increasing number of available production pathways with different characteristics in terms of GHG emissions, production costs and potentials, allows the MSs to apply different biofuel strategies, favouring specific types of biofuels depending on the objectives underlying their own biofuel support policy.

However, the use of tax exemptions or reliefs provokes a loss in public revenue. In Lithuania, the State Tax Inspectorate estimated that the excise duty relief to biofuels sold in the domestic market amounted to EUR 22.32 M in 2009 (Lithuania) [28]. In Poland, the excise duty exemptions granted in 2009 for the use of biocomponents in fuels amounted to approximately PLN 1048 M; the equivalent figure for biocomponents intended for fuel was approximately PLN 183 M (Ministry of Economic Affairs of Poland [29]. This explains the switch, observed in recent years, from this type of measure to obligation schemes (see the case of Hungary). The case of Belgium is also interesting in that, in order to overcome revenue losses, the authorities promoted a simultaneous increase of the fossil fuel tax so as to render the policy budget-neutral.

Table 3 summarises our analysis and offers an overview of the MSs that implemented tax incentives to promote biofuel uptake in recent years.

4. Biofuel blending mandates

Some MSs implemented biofuel blending mandates, either separately or in conjunction with other fiscal measures, to boost the use of biofuels in the transport sector.

Biofuel blending mandates are implemented by each MS so that the quotas set by them through their respective legislations are legally binding for fuel suppliers. Thus, the blending rate shows the mandatory requirements on the biofuel share of the total transport fuel that is sold. Fossil fuel suppliers have an obligation to supply a certain percentage of biofuel in their total fuel sales. They provide evidence of this by redeeming renewable transport fuel certificates. Blending mandates do not always adopt the same form. In some cases, biofuel blending mandates only refer to a specific percentage of biofuels that the suppliers have to place in the market, through the sale of either pure biofuels or as blends with traditional fuels. In other cases, the suppliers are required to blend their fuels with a minimum proportion of biofuel, thereby establishing minimum requirements for diesel and petrol.

According to Wiesenthal et al. [9], one of the main advantages of the biofuel blending mandate system is the predictability of the

[9] Hernández et al. [26] analysed for the Spanish case if biofuels might become competitive in the future without governmental aids.

[10] Article 16 of Directive 2003/96/EC [27] establishes that the MSs will be entitled to apply, under fiscal control, tax exemptions or tax reliefs to products falling within CN Code 3824 90 99 when they are intended for use as motor fuel.

[11] Council Directive 2003/96/EC [27], of 27 October 2003, restructuring the Community framework for the taxation of energy products and electricity.

Table 3
Tax incentives to promote biofuel consumption (2005-2010).
Source: Pelkmans et al. [12] and own elaboration.

	Low biodiesel blends (B5)	B30	B100	Low ethanol blends (E5/ETBE)	E85	PPO
Austria	✓		✓	✓	✓	✓
Belgium	✓				✓	✓
Bulgaria	✓		✓	✓		
Cyprus	✓		✓	✓		
Czech Rep.	✓	✓				
Denmark	✓			✓		
Estonia	✓			✓		
Finland						
France	✓	✓		✓	✓	
Germany	✓		✓	✓	✓	✓
Greece	✓					
Hungary	✓			✓	✓	
Ireland	✓		✓	✓	✓	✓
Italy	✓	✓				
Latvia	✓	✓	✓	✓	✓	✓
Lithuania	✓			✓		
Luxembourg	✓		✓	✓		✓
Malta	✓					
The Netherlands	✓			✓		✓
Poland	✓	✓	✓	✓		
Portugal	✓					
Romania	✓			✓		
Slovakia	✓			✓		
Slovenia	✓		✓	✓		
Spain	✓			✓		
Sweden	✓		✓	✓	✓	
UK	✓			✓		

Table 4
Biofuel Blending Mandates. 2011.
Source: Kingsman (2011) and own elaboration.

	Biofuel Blending Mandates—National incorporation rates (% energy, unless otherwise specified)		
	Bioethanol blending obligations	**Biodiesel blending obligations**	**Biofuel mandate**
Germany	Min. 2.8	Min 4.4	6.25
Austria	Min. 3.4	Min.6.3	5.75
Belgium	4 (vol.)	4 (vol.)	
Bulgaria*	2 (vol.)	4 (vol.)	5 (vol.)
Cyprus			2.5 (target)**
Denmark			3.5
Slovakia	Min. 3.1 (vol.)	Min. 5.2 (vol.)	5.75
Slovenia			2.8 (target) **
Estonia			5.75 (target) **
Spain	Min. 3.9	Min. 6	7
Finland			6
France	7	7	7
Greece			5.75 (target) **
Hungary	Min. 4.4 (vol.)	Min. 4.4 (vol.)	5.75
Ireland			4 (vol.)
Italy			4
Latvia	5 (vol.)	5 (vol.)	5
Lithuania			5.75 (target) **
Luxembourg			5.75 (target) **
The Netherlands	Min 3.5	Min 3.5	4.25 (vol.)
Malta			5.75 (target) **
Poland			6.2
Portugal		7 (vol.)	5.75 (target) **
United Kingdom			4 (vol.)
Czech Republic	4.1 (vol.)	6 (vol.)	
Romania	5 (vol.)	5 (vol.)	5.75
Sweden			5.75

* Bulgaria has postponed the implementation of its blending mandates until 2013.
** This percentage does not correspond to a biofuel blending mandate but to an indicative target.

market volumes that will be reached in a specific year. In this way, the system not only guarantees a specific volume of biofuel consumption for transport but it also establishes a predictable long-term framework for biofuel suppliers who will have to adjust the demand of biofuel under increasingly rigorous circumstances with respect to renewable energies as a percentage of total energy consumption.

The percentages and the structure of the blending rates established in each country vary significantly. In addition, they have changed over the years and have been progressively implemented. Table 4 shows the biofuel blending rates currently established by the different MSs. The second column in the table shows the amounts of bioethanol that must be compulsorily blended with petrol before being sold, either as energy content incorporation rates or as percentages of bioethanol content by volume. The third column shows the blending rates of biofuel with diesel, which countries also express as energy content by volume. Finally, the last column shows compulsory biofuel blending rates. Some countries, in addition to establishing compulsory biofuel blending rates for petrol and diesel, stipulate the percentage of biofuel that fuel suppliers must certify as having been sold. Other countries do not establish compulsory quotas for petrol or diesel, but provide percentage quotas for biofuels in general. Biofuel percentages in fuels as reflected in the last column are also expressed as energy content by volume, according to the dispositions of each country's legislation. Only eight countries have yet to include any kind of biofuel blending mandate in their legislations, having only defined the indicative targets as stipulated in the Renewable Energy Directive. These MSs are Cyprus, Slovenia, Estonia, Greece, Lithuania, Luxembourg, Malta and Portugal. These countries' indicative targets are also reflected in the last column of Table 4, enclosed in brackets.

The establishment of the blending mandates is recent, with most countries adopting these measures at the end of 2008 or during 2009. Nevertheless, some countries like Germany, the Czech Republic, The Netherlands, Spain and Portugal had already applied these measures beforehand.

Suppliers commercialise biofuels with various names depending on the actual percentage of biofuel contained in them. Consumers can thus identify more easily the blend they need according to the technical characteristics of their vehicles. In France, for instance, E10 fuel (containing 10% ethanol) has been sold since April 2009, while in Sweden, E85 fuel (containing 85% ethanol) has been on the market since 2007. In The Netherlands, E10 fuel has been introduced, although its use is not yet extended. For the commercial success of these biofuel blending mandates, it is essential that their introduction into the market is made hand in hand with technical changes in vehicles and the diffusion of adequate information to the population. For this reason, the penetration of these products into the market has been gradual and not as rapid as initially forecast by governments. As a consequence of this, Germany in June 2009 had to reduce its biofuel blending mandate for 2010 from 6.25 to 5.25%. The United Kingdom similarly reduced its mandate (EurObserv'ER) [4]. In order to correctly adapt these products to vehicle requirements, some countries have incorporated into their legislations not only the amounts of biofuel that fuels should contain, but also the maximum amounts that they can contain, with the aim of guaranteeing that the resulting blends are suitable for vehicles. This is the case, for instance, in France and Portugal.

5. Discussion

From the entry into force of Directive 2003/96/EC [27] through until 2010, the EU-27 has promoted the use of biofuels for

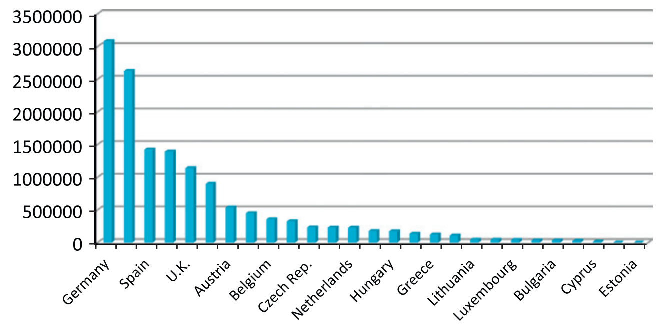


Fig. 1. Biofuel consumption for transport in EU (2010) (Mtoe).
Source: EurObserv'ER [4].

transport. The consumption of these products increased by 148.2% between 2006 and 2010—from 5601.7 Mtoe to 1209 Mtoe. Nevertheless, this increment was not homogeneous over that period. The consumption of biofuels by the transport sector only increased by 18.7% between 2008 and 2009, compared to 30.3% between 2007 and 2008 and 41.8% between 2006 and 2007, highlighting the fact that the annual increase was much faster during the initial years (EurObserv'ER) [4].

The actions of EU-27 MSs with respect to promoting biofuel consumption by the transport sector between 2006 and 2010 were very heterogeneous, meaning that MSs have not evolved in the same way and their consumption has not been equally significant in all cases. Fig. 1 shows biofuel consumption in the transport sector for the EU-27 countries in 2010, with Germany, France, Spain, Italy and the UK, closely followed by Poland, having reached a level of biofuel consumption above 1000 Mtoe.

However, the starting point for these countries in 2006 was very different. Table 5 shows that Germany, followed close by France, was the only country where biofuel consumption for transport amounted to more than 1 Mtoe in 2006. Next, with less than half of Germany's consumption, were Austria and Sweden. Table 5 also shows that the effort made by the different countries to increase the consumption of biofuels by the transport sector was also very different. The increase experienced in the period between 2006 and 2010 by countries such as Belgium, Finland, Romania, Luxembourg and Ireland, as well as Hungary, Slovakia and the Czech Republic, warrants comment. Data for these countries demonstrate that the countries where biofuel consumption increased the most as a proportion of total fuel use between 2006 and 2010 are not the same as those that reached the highest levels of consumption in 2010. In particular, the countries where consumption increased the most are precisely those that started from lower consumption levels in 2006.

Several considerations are forthcoming both from an analysis of the evolution of biofuel consumption in the transport sector in the EU between 2006 and 2010, as well as scrutiny of the measures implemented by the MSs to promote biofuel consumption. First, with the exception of Finland, most countries applied tax incentives to promote biofuel consumption in the transport sector. Moreover, countries that reached higher levels of biofuel consumption in 2010, i.e., Germany, France and Spain (see Fig. 1), are precisely the countries that implemented a broader range of tax incentives during the period in question. These incentives consisted of tax reliefs on mineral oil duties (Germany and Spain), on domestic consumption tax (France), and on vehicle registration tax for flexible fuel vehicles (Spain), and taxes on the release for consumption of petrol and diesel (France and Spain).

In addition to tax incentives, MSs also introduced blending mandates to increase biofuel consumption in the transport sector.

Table 5
Biofuel consumption by the transport sector in the EU (2006-2010) (Mtoe).
Source: EurObserv'ER [30].

Countries	2010	2006	% (2006–2010)	Biofuel mandate
Belgium	0.358	0.001	39,814.83	
Finland	0.136	0.001	16,524.39	6
Romania	0.231	0.003	8,283.90	5.75
Luxembourg	0.041	0.001	7,476.77	5.75(target)
Ireland	0.109	0.003	3,452.83	4 (vol.)
Hungary	0.175	0.012	1,356.42	5.75
Slovakia	0.178	0.013	1,250.31	5.75
Czech Rep.	0.234	0.019	1,103.07	
Latvia	0.027	0.002	991.67	5
Slovenia	0.045	0.004	947.11	2.8 (target)
Denmark	0.035	0.004	869.23	3.5
Poland	0.901	0.095	850.85	6.2
Italy	1.394	0.149	835.75	4
Spain	1.426	0.169	745.56	7
The Netherlands	0.229	0.032	616.46	4.25 (vol.)
U.K.	1.140	0.180	532.47	4 (vol.)
Portugal	0.326	0.070	363.62	5.75
Bulgaria	0.034	0.008	318.18	–
France	2.629	0.737	256.58	7
Greece	0.125	0.046	168.76	5.75 (target)
Lithuania	0.045	0.019	132.70	5.75 (target)
Sweden	0.452	0.222	103.01	5.75
Austria	0.537	0.333	61.20	5.75
Malta	0.001	0.001	5.87	5.75 (target)
Germany	3.082	3.475	−11.30	6.25
Estonia	0.000	0.001	−100.00	5.75 (target)
Cyprus	0.358	0.001		2.5(target)

This measure, which was adopted early on in Finland, is considered to be very effective. In particular, the considerable increase of biofuel consumption for transport in the case of Finland is, to a significant extent, due to the compliance of that country with the biofuel blending mandate. In addition, France, Spain and Germany established more demanding biofuel blending mandates and subsequently reached higher levels of biofuel consumption by the transport sector in 2010. It can also be shown that countries that have not yet implemented biofuel blending mandates, such as Estonia, Malta and Cyprus, reached much lower levels of biofuel consumption for transport.

Together with these considerations, it is necessary to point out that policies promoting biofuel consumption are not unanimously accepted by experts.[12] First, the usefulness of these policies in the fight against climate change has been called into question, and second, doubts have been cast on whether they effectively reduce energy dependence in the EU. In relation to their effectiveness in the fight against climate change, the argument is that, contrary to what happens with the public promotion of green electric power or the use of renewable energies for heating and cooling, public support for the use of biofuels for transport does not incorporate any adequate sustainability criteria.[13] Due to this criteria is one of the main objectives of the EU energy policy, as reflected in Article 194 of the Treaty of Lisbon [6], the contribution of the increment of biofuel consumption in the transport sector to the reduction of GHG emissions is disputed.

The most recent criticism of this policy to promote biofuel consumption is based on the contribution by Searchinger et al. [33], who underlined the need to include biofuels' indirect impact on land use into the balance of GHG emissions. This indirect impact ("indirect land use change", ILUC) is related to the fact that the partial use of the agrarian production to obtain biofuels leads to the cultivation of lands that until that moment were used

[12] See Liao et al. [31].
[13] For the EU case, see Soimakallio and Koponen [32].

as CO_2 drains.[14] The controversy generated by the publication of Searchinger et al. [33] was aggravated when, in April 2009, the State of California included ILUC into the list of quality standards that biofuels had to satisfy from 2011. In a similar way, in December 2008, the European Parliament approved the introduction of amendments to the Directive on environmental quality standards for fuel (Directive 2009/30) [35]. These amendments incorporated the European Commission mandate to develop a methodology that includes ILUC into biofuels' GHG emission balance (European Commission) [36].[15]

On the other hand, Melillo et al. [39] suggested, among other measures, the need to introduce a minimum requirement of 60% GHG emission savings for all biofuels compared to fossil fuels, to improve the established sustainability standards for biofuels or to establish a proper calculation method for GHG emissions. In short, the increase of biofuel consumption in itself cannot be considered a success as long as it does not help reduce the GHG emissions of the transport sector. For this reason, biofuels need to be checked against their GHG emissions with the help of a robust and credible calculation system. In this sense, as Wiesenthal et al. [9] pointed out, the use of differentiated tax rates may be convenient to favour specific types of biofuel to better serve the objectives underlying biofuel support policies.

Due to the relevance given to sustainability, Directive 2009/28/EC [20] introduced legal restrictions to guarantee its success within the context of the EU-27. According to the sustainability criteria established in Directive 2009/28/EC [20], the reduction of GHG emissions derived from the use of biofuels must reach a minimum of 35%. This directive is very exacting in what concerns the sustainability criteria[16] of biofuel production, prescribing only those methods that allow significant reductions of GHG emissions. Nevertheless, its legal requirements exceed the period of time considered in this article.[17]

Other reservations about the policy call into question the usefulness of the increase of biofuel consumption to reduce energy dependence in the EU. In 2007, almost 15% of the biofuels consumed in the EU was imported, while in 2008, the proportion had increased to 25% (Commission Staff Working Document SEC) [40]. A recent publication by GBI Research [41] states that if the policy promoting biofuel consumption for transport in the EU is not implemented simultaneously with the necessary technological progress and the increase in the availability of land for the production of feedstock, it will be very difficult to satisfy the demand for biofuel by the transport sector in Europe with domestic production only. Anycase, this is not an easy question for policy makers (Di Lucia et al.) [42].

Despite these criticisms, biofuel support policies in the transport sector of the EU-27 were maintained, although biofuel consumption by the transport sector did not exceed 4% (12 Mtoe) of the total in 2009 and 4.8% (15 Mtoe) in 2010, far from the objective of 5.75% (18 Mtoe) fixed for this last year (EurObserv'ER) [4].

6. Conclusions

The need to identify alternatives to fossil fuel energy sources has been accentuated by oil price rises as well as the EU commitment to achieve a reduction of GHG emissions. Government authorities have thus focused attention on the transport sector, which is responsible for more than 30% of the energy consumed in the EU and is 98% dependent on fossil fuel sources.

The main objectives of Directive 2003/30/EC [1] and thereafter the binding objectives specified in general terms in Directive 2009/28/EC [20], have been transposed to the respective legislations of all EU countries to comply with demands regarding the share of renewable energies in the total energy consumption of the transport sector in 2010 and 2020. Tax incentives and biofuel blending mandates have been the tools most frequently used by MSs to promote the consumption of biofuels by this sector. Nevertheless, the application of these measures differs notably between countries.

Tax incentives have contributed to directly boost biofuel consumption to the detriment of fossil fuels, granting consumers various tax reliefs or, under certain circumstances, total tax exemptions. All MSs, with the exception of Finland, apply this measure. Subsidies through partial or total exemption (complemented by other measures) have proved to be the most successful instrument in creating a market niche for biofuels. Additionally, tax exemptions have the ability to steer the market though the application of different reduction rates to various types of biofuels. The data on biofuel consumption in the transport sector and the way tax incentives have been implemented indicate that the French and the Spanish incentive systems are particularly conducive to the development of biofuels.

At the same time, tax reliefs represent a loss of public revenues that, in a period of financial difficulties such as the current global financial crisis, is probably difficult to resist in the long run without compensation from other sectors. For this reason some countries, like Belgium, have been forced to increase other taxes in order to compensate for the loss. Others, like Hungary, have switched from incentives to obligation schemes. In other cases, such as in Germany, biofuel consumption for transport as a percentage of the total energy consumption has radically dropped from 7.3% in 2007 to 5.9% in 2008 and 5.5% in 2009.

The implementation of biofuel blending mandates seems to have better prospects, although in most countries they are combined with tax incentives. Blending mandates are revised each year in line with the capacity of countries to increase the biofuels production and steer the market towards an increased on biofuels consumption. It is thus possible to observe how in the last year (2010–2011) the consumption and production of biofuels has risen in Poland, Italy, Spain, Bulgaria, Sweden and Finland, with Denmark entering this group for the first time. The countries with more demanding biofuel blending mandates in 2011 were Germany, France and Spain, which were also the countries with broader tax incentive policies and higher levels of biofuel consumption in 2010.

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[14] This question is also related with the posibility that biofuels production would increase food prices although recent research as Ajanovic [34] does not find evidence in that sense.

[15] Biofuels with an adequate emission balance would comply with the new sustainability criteria and would obtain "green certificates" that allow their commercialisation in the EU. Biofuel standards were introduced as early as 1991 in Austria, followed by France and Germany in 1992 and 1994. As a result of the national standards, an EU-wide biodiesel standard was introduced in 2004 (EN 14214). Two recent analysis of this issue can be found in Scarlat and Dallemand [37] and Overmars et *al.* [38].

[16] On June 10, 2010, the European Commission set the sustainability criteria to be applied to biofuels from December 5, 2010, and specified what should be done to ensure that only sustainable biofuels were used.

[17] This measure did not enter into force until December 5, 2010.

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Annexe A

See Table A1.

Table A1
Tax relief details.

Austria	Since 1991, pure biodiesel has enjoyed a full tax exemption in Austria's mineral tax and since 2007 a tax reduction has also been applied to petrol blended with bioethanol. From September 2007, petrol and diesel with a minimum biogenic substance content of 44 l (per 1000 l) and a maximum sulphur content of 10 mg/kg have enjoyed reduced rates of duty. Pure biofuels are fully exempt from mineral oil duties (Federal Ministry for Agriculture, Forestry, the Environment and Water Management)[43].
Bulgaria	Biofuel blends have enjoyed a reduction of the rate of excise duty from 24 November 2009. These reduced rates were valid for 2 years. Pure biodiesel is fully exempt from the excise duty on motor fuels (Ministry of Economy, Energy and Tourism)[44].
Czech Republic	In 2009, excise duty stood at CZK 9950 per 1000 l for diesel and CZK 11,840 per 1000 l for petrol. The rate applied to diesel blends was CZK 6866 per 1000 l. E85 fuel is taxed at the same rate as petrol but the taxpayer is entitled to a refund when it is released for free circulation. Pure FAME (Fatty Acid Methyl Esters) and FAEE (Fatty Acid Ethyl Ester), vegetable oils, E95 fuel (in the context of a pilot project), liquefied biogas and second-generation biofuel are fully exempt (Czech Republic)[45]. In the event of a failure to comply with the quota obligations, Act No. 86/2002 [46] on air protection stipulates a penalty of CZK 40 per litre of biofuel not put into free circulation.
Denmark	As of 1 January 2005, biofuels have been exempt from the CO_2 tax imposed on the use of conventional petrol and diesel for transport purposes (Denmark) [47].
Estonia	Biofuels are exempt from excise duty (Alcohol, Tobacco and Fuel Excise Duty Act); particularly those falling within CN code 4401 or 4402 are unconditionally exempt from excise duty (Estonia) [48].
France	The French incentive system is particularly conductive to the development of biofuels. Since 1992, biodiesel has enjoyed total exemption from the internal tax on oil products (TIPP). In the case of bioethanol incorporated into petrol as ETBE, the exemption is partial (80%). Since 1 January 2007, pure vegetable oils have been exempt from the domestic consumption tax when they are used as agricultural fuel. Biofuels enjoy partial exemption from the domestic consumption tax. With this measure, the French government has attempted to offset the additional cost of producing biofuels compared to fossil fuels. In 2010, the amounts exempt from the domestic consumption tax were 11€/hl for FAME, 18€/hl for ETBE (ethyl-tertiary butyl ether) and ethanol, 18€/hl for vegetable oil ethyl esters and 11€/hl for synthesis biodiesel (France) [49]. An interesting tax reform was implemented in France in 2005. In order to raise the market share of biofuels, the French Parliament introduced a general tax on polluting activities (GTPA) for fuel resellers. GTPA is zero if an annual target percentage of biofuel is reached.
Germany	The tax relief for pure vegetable oil and pure biodiesel (B100) outside the quota has been reduced to a tax rate of 18 cents per litre (Germany) [50]. In fact, the tax levied on vegetable oil rose from €0.099/litre in 2008 to €0.182/litre in 2009, while the tax on B100 increased from €0.149/litre to €0.183/litre, which is the same as for blended biodiesel. The tax levied increased to €0.185/litre for vegetable oil and €0.186/litre for B100 in 2010. A scheme similar to the French one was introduced in Germany after 2006, when the government switched from tax exemption policies to obligation schemes. The German authorities introduced penalties in the case of non-compliance with the annual targets for biofuel consumption. Penalties for non-compliance were set rather high ($>$ 0.50euros/litre). As pointed out in Pelkmans et al. [12], this represented a good motivation for fuel distributors to fulfil the obligation.
Hungary	Tax differentiation for biofuels ended as of 1 July 2009. The current financial legislation does not offer any tax relief for biofuel volumes contained in blends (Covrig) [51].
Ireland	In 2005, the Department of Communications, Marine and Natural Resources rolled out a pilot scheme for mineral oil tax reliefs for biofuels, which culminated in 8 projects (4 pure plant oil, 3 biodiesel and 1 bioethanol) being approved for excise relief over a two-year period commencing in August 2005. Following on the success of the pilot biofuel scheme, a five-year package of excise relief was announced in the context of the country's 2006 budget. The four pilot projects ended on 31 December 2010 and were substituted by the National Biofuel Obligation. Electric vehicles enjoy full tax exemption from vehicle registration tax (VRT). Plug-in hybrid electric vehicles and FFV enjoy VRT reliefs of up to €2500 (Department of Communications, Energy and Natural Resources) [52].
Italy	From 1 January 2007 to 31 December 2010, biodiesel enjoyed a rate of excise duty reduced to 20% of that applicable to diesel (€423 per 1000 l). A similar scheme is applied to certain fuels and additives (ETBE) obtained from plant ethanol (Ministry of Economic Affairs and Finance) [53].
Latvia	Petroleum products blended with biofuel have enjoyed reduced rates of excise duty as from 1 February 2009 (Latvia) [54].
Lithuania	Zero-rate excise duty is applied to dehydrated ethyl alcohol. The excise duty relief applied in 2009 was as follows: €10,645 for bioethanol blended with motor spirit per 1000 l and €11,675 for FAME blended with diesel (Lithuania) [28]. Focusing on Lithuania, (Covrig)[51] states that biofuels, and especially biodiesel, seem to be a profitable business for the country even if only high blends of over 30% have full tax exemption (on the renewable portion of the fuel mix). Natural or legal persons who emit pollution from vehicles using biofuels are exempt from the tax on environmental pollution from mobile sources.
Netherlands	At the end of 2009, The Netherlands decided to reduce the excise duty on sustainably produced E85 biofuel by 27% from 1 April 2010, given the lower energy content of E85 fuel compared with petrol (Netherlands) [55].
Malta	The main instrument used for the promotion of biofuels in Malta is the exemption from the payment of excise duty on the biomass content (its percentage) in biodiesel granted by the government (Ministry for Resources and Rural Affairs) [56].
Poland	The products exempt from excise duty are biocomponents intended for use in liquid fuels and liquid biofuels and meeting relevant quality requirements (Ministry of Economic Affairs) [29].
Portugal	Portugal applies a partial exemption from excise duty (especially in oil and energy tax) for biofuels. Total exemptions are applied to dedicated small producers of products that are more environmentally friendly (Directorate-General for Energy and Geology) [57].
Romania	Romania applies an exemption from the payment of the excise duty for biofuels and other renewable fuels. In relation to the effects of these measures, (Covrig) [51] states that the tax relief of €0.011–0.035/litre for the biofuel volume in the blend does not seem to have helped much in encouraging production.
Spain	Together with France, the Spanish incentive system is particularly conducive to the development of biofuels as they enjoy total exemption from the hydrocarbons tax until 31 December 2012. This special rate is applied to the biofuel volume contained in the mixture. In 2007, Spain implemented a reduction in the vehicle registration tax for vehicles using biofuels (Cansino & Ordoñez) [58].
Slovakia	Exemption from excise duty applies to fuel blends of petrol with ETBE and diesel with esters; the reduction in excise duty for these fuel blends is stipulated for a biofuel proportion of up to 7.05% and 5% by volume, respectively. This measure is to be applied for a period of six years (2007–2013).
Slovenia	Slovenia applies full exemption for the biodiesel and ethanol parts of the blend up to a maximum 5% (Covrig) [51].
Sweden	Tax exemption for ethanol has been applied in Sweden since 1992, but a full tax exemption has only been permitted for all types of biofuel in the case of pilot projects implemented since 1995.
UK	Biodiesel and bioethanol received a £0.20 per litre fuel duty incentive until 31 March 2010 [59].

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